

**LICK SLIT SPECTRA OF THIRTY-EIGHT
OBJECTIVE PRISM QSO CANDIDATES
AND LOW METALLICITY HALO STARS ¹**

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ABSTRACT

We present Lick Observatory slit spectra of 38 objects which were claimed to have pronounced ultraviolet excess and emission lines. Zhan & Chen selected these objects by eye from a UK Schmidt telescope IIIaJ objective prism plate of a field at $0^{\text{h}} 0.0^{\circ}$ ($l \simeq 98^{\circ}$, $b \simeq -60^{\circ}$). We concentrated on $m_J \simeq 18$ –19 objects which Zhan & Chen thought were most likely to be QSOs at redshift $z_{em} \geq 2.8$.

Most of our spectra have FWHM spectral resolutions of about 4 \AA , and relatively high S/N of about 10–50, although some have FWHM $\simeq 15 \text{ \AA}$ or lower S/N. We find eleven QSOs, four galaxies at $z \simeq 0.1$, twenty-two stars and one unidentified object with a low S/N spectrum.

The ZC lists are found to contain many QSOs at low z but few at high z , as would be expected. Of eleven objects which ZC suggested were QSOs with $z_{prism} \leq 2.8$, eight (73%) are QSOs. But only three of twenty-five candidates with $z_{prism} \geq 2.8$ are QSOs, and only two (8%) of these are at $z \geq 2.8$. Unfortunately the ZC prism redshifts are often incorrect: only five of the eleven QSOs are at redshifts similar to z_{prism} .

Six of the QSOs show absorption systems, including Q0000+027A with a relatively strong associated C IV absorption system, and Q0008+008 ($V \simeq 18.9$) with a damped Ly α system with an H I column density of 10^{21} cm^{-2} .

The stars include a wide variety of spectral types. There is one new DA4 white dwarf at 170 pc, one sdB at 14 kpc, and three M stars. The rest are of types F, G and K. We have measured the equivalent widths of the Ca II K line, the G-band and the Balmer lines in ten stars with the best spectra, and we derive metallicities. Seven of them are in the range $-2.5 \leq [\text{Fe}/\text{H}] \leq -1.7$, while the others are less metal poor. If the stars are dwarfs, then they are at distances of 1 to 7 kpc, but if they are giants, typical distances will be about 10 kpc.

Subject Headings: quasars: general – galaxies: distances and redshifts – stars: fundamental parameters – white dwarfs – surveys

1. INTRODUCTION

Zhan & Chen (1987a,b, 1989a,b, hereafter ZC1, ZC2, ZC3 and ZC4) presented lists of several hundred QSO candidates, which they selected by eye from a single UK Schmidt telescope IIIaJ objective prism plate. The candidates were chosen because they had emission lines and UV excess in the range 3200–5400 Å, and each was assigned a reliability index, $Q = Q_1 + Q_2$, where Q_1 was 1, 2 or 3 for increasing strength of emission lines, and Q_2 was similarly valued for increasing strength of UV excess.

We have obtained slit spectra of 38 of these QSO candidates with the Lick Observatory 3 m telescope, on three separate occasions, during unrelated projects. Two of the objects have $Q = 6$, thirty-four have $Q = 5$ and the remaining two, with $Q = 4$, are the least likely to be QSOs. Since $Q \geq 4$ for all thirty-eight objects, all should have both emission lines and UV excess.

Table 1 is a journal of our observations, with the instrumental setup (§2 below), wavelength range and integration time. We also give the reference to the Zhan & Chen paper which contains the object coordinates, magnitude and finding chart. Note that these charts have East to the right, and that the English translation of ZC3 lacks charts, while for the other papers the charts are often better in the translation.

2. OBSERVATIONS

Our spectra were taken in support of three different observing programs, at three different times, and with three different instrumental setups, although in all cases we used a Cassegrain spectrograph with the Shane 3-m telescope at Lick Observatory.

2.1 Setup A: Ten $z \simeq 3$ Objects

These targets were selected as bright QSO candidates with $z_{prism} \simeq 3$. They were selected and observed by VTJ and RDC.

The UV Schmidt camera was used on the Cassegrain spectrograph (Miller & Stone 1987) with a 300 g/mm grating blazed at 4230 Å in first order. A thinned TI 800×800 CCD with 15 μ pixels, and 7 e[−] readout noise was used, giving 3.9 Å per pixel across 3100 Å. All observations were made on October 4, 1988, when the sky was clear and the seeing was about 1 arcsecond. For the ten program objects we used a wide 2.88 arcsecond slit, giving a FWHM resolution of 3.5 pixels, which is 14 Å, but for the flux standard star we used a 7.9 arcsecond slit. The slit was not rotated to the parallactic angle, but it was rotated to $PA = 248^\circ$ to simultaneously record 0003+011A & B, and to $PA = 92^\circ$ for 0011–002A & B. Hour angles ranged from 2 hours 30 minutes East to 3 hours 10 min West. All exposures were 600 seconds, and the spectra were reduced in the usual way.

2.2 Setup B: Eleven Intermediate z Objects with Close Neighbours

These eleven QSO candidates were observed on August 24 or 27, 1990 by DT and FXM to search for Mg II absorption systems which might show large scale ($\simeq 100 h^{-1}$ Mpc) correlations in three dimensions. This program was motivated by the finding of Tytler et al. (1987) that a few QSOs each had more Mg II systems than were expected if they were all intervening, a two sigma result which has since been refuted by much larger samples which do not show any sign of such correlations (Sargent et al. 1988; Steidel & Sargent 1992, Tytler, Sandoval & Fan 1993 §2.4). The QSO candidates which we observed were chosen because they had one or more neighbours within about 1° . Here we present our observations of only the ZC QSO candidates, two of which were also observed by VTJ and RDC with setup A. Other QSOs observed in this program will be discussed elsewhere.

Spectra were obtained with the Cassegrain spectrograph using a 600 g/mm grism, blazed at 4840 Å in first order (Miller and Stone 1987). We used a thinned TI 800×800 CCD with 15 μ pixels, and 7 e[−] readout noise, giving 3.43 Å per pixel from 4312 to 7059 Å. The wavelength range was chosen to maximize the chance of detecting redshifted Mg II absorption line systems, and it unfortunately misses blue wavelengths which are most useful for stellar spectral classification. A 2.09 arcsec slit was used giving a FWHM resolution of 2.5 pixels, which is 8.6 Å. The slit was not rotated to the parallactic angle, but the spectra were reduced in the usual way.

2.3 Setup C: Nineteen High z Objects

Nineteen QSOs were observed by DT in November 1992 with the superb new Kast double spectrograph, which records blue and red spectra simultaneously. We used a dichroic with a nominal wavelength of 5500 Å. Light with wavelengths to the blue of this were dispersed with a 600 g/mm grism blazed at 4310 Å, while the red light was dispersed by a 600 g/mm reflection grating blazed at 7500 Å. A thinned Reticon 1200×400 CCD was used in each of the blue and red cameras. In the blue we recorded from 3320 to 5485 Å with 1.81 Å per pixel, and a two pixel FWHM of 3.6 Å, and in the red from 5530 to 8270 Å with 2.34 Å per pixel and a two pixel FWHM of 4.7 Å. A 1.5 arcsec slit was used, and was rotated to the appropriate parallactic angle. The sky was clear, the seeing about 1.5 arcseconds, and the spectra were reduced in the usual manner.

3. RESULTS

We first discuss various problems with the spectra, then slit magnitude and color estimates.

3.1 The Spectra

The spectra shown in Figure 1 are grouped by setup (A, then B, then C) to make spectral features easier to identify. The flux is f_ν , in units of micro-Jansky, and all wavelengths given in this paper are vacuum, but they are not heliocentric. Wavelength scales should be accurate to about one pixel or better. A one sigma error trace is shown beneath the spectra from setups B and C. Peaks in the error correspond to sky emission lines. Note that poorly subtracted sky emission lines can appear as emission and/or absorption in the spectra. In setup B there is frequently a bogus absorption at the extreme blue end of the spectrum (4311 Å), a bogus emission feature near 4325 Å, and a second bogus absorption near 4370 Å. The former two arise from poor flux calibration, while the third is bad sky subtraction.

For setups A we did not attempt to correct for atmospheric absorption, hence the B band (6867 Å) is visible. For setups B and C we did use early type star spectra to attempt to remove the B band, the A band (7600 Å), and OH absorption at 7160–7340 Å but with varying success.

The spectra have been corrected for atmospheric extinction, but not for interstellar extinction ($b \simeq -60^\circ$). Table 2 is a summary of our results.

3.2 Slit Magnitudes

Magnitudes listed by ZC were obtained from image sizes on a direct Schmidt plate, using the King et al. (1981) calibration of the dependence of B_J magnitude on image size. ZC5 noted that these magnitudes may be too bright by 0.5 – 1.0 mag. because they found most objects at $\simeq 18.5$, a whole magnitude brighter than the peak of the otherwise similar survey by Savage et al. (1984). However Hörtnagl, Kimeswenger & Weinberger (1992) have shown that King et al. measured larger image diameters at a given m_j , which suggests that the ZC magnitudes may actually be too faint, rather than too bright, for $m_j \geq 18$. We can not determine which is correct because we do not know how ZC measured image sizes.

To try to reduce this uncertainty, we have estimated magnitudes from our slit spectra. These magnitudes are highly uncertain because we used narrow slits. A broad band flux F is defined as

$$F = \frac{\int_{\lambda_{min}}^{\infty} T(\lambda) f(\lambda) d\lambda}{\int_{\lambda_{min}}^{\infty} T(\lambda) d\lambda}, \quad (1)$$

where $T(\lambda)$ is the band transmission (Kitchin, C.R. 1984), $f(\lambda)$ is the flux per unit wavelength, and λ_{min} is ideally $-\infty$, but in practice was the minimum wavelength of the spectrum. For setup C we added an estimate of the flux in the dichroic filter gap, which was only 20 Å. We obtained magnitudes from $U = -2.5 \log_{10} F_U + K_U$, and similarly for B and V, where the constants K_U , K_B and K_V were obtained from the standard star spectra.

Our slit magnitudes are listed in Table 3. They have automatically been corrected for atmospheric extinction by the usual flux calibration process, which converts from recorded photoelectrons to flux above the atmosphere, as a function of wavelength. Galactic reddening $E(B-V)$ values from Burstein & Heiles

(1982) are 0.01, 0.02, or 0.03 for the targets. The colors $(B-V)_0$ listed in Table 3 have been corrected for these reddening values, but we have not corrected the individual magnitudes because their zero point errors are much larger than the corrections of $A_V \simeq 0.03 - 0.09$.

We have checked our magnitudes in five ways. First, we calculated a magnitude from each of our thirteen standard star spectra. We obtained standard deviations of $s = 0.17$ magnitudes for the V magnitudes and $s = 0.21$ for the B magnitudes, which we regard as lower bounds on the external errors of our other magnitude measurements.

Second, two objects were observed twice, and in both cases the magnitudes were 0.7 – 1.0 fainter in setup A, because a wider slit was used for the flux standard than for the program objects, although the $(B-V)$ colors differ by much less (0.02 and 0.14).

Third, when we compare our slit $(B-V)$ colors with those estimated from the strength of the Balmer lines in §3.4 below, we find excellent agreement which suggests that our slit $(B-V)$ colors from setup C (the only ones to have the slit aligned to the parallactic angle) have a 1σ error of under 0.04 mag.

Fourth, in Figure 2 we show the difference between our slit B magnitudes and the ZC image size B_J magnitudes. Ours are on average 1.4 magnitudes fainter. ZC5 noted that their magnitudes were probably too bright, but they guessed by only 0.5 – 1.0 magnitudes, which suggests that some of our magnitudes may be too faint. We do not see any systematic differences between our three setups.

Fifth, four of the QSOs (0004-005B, 0006+020B, 0006+025 and 0010-002B) have been found independently by Foltz et al. (1989). Their B_J magnitudes, which we list in §6, are brighter than ours by 0.3, 0.54, 1.19 and 1.57 magnitudes respectively, where the first three are from setup B, and the last one is from setup A.

These tests suggest that our colors, but not necessarily the individual magnitudes, from setup C are good. Both the magnitudes and colors from setups A and B setups are also suspect because the slit was narrow (1.5 to 2.88 arcsec), it was not rotated to the parallactic angle, and the TV camera guides on the red, so we expect that the B and especially the U magnitudes will be systematically too faint, and the V magnitudes should be the least bad. In addition there are several reasons why we expect our magnitudes for the program objects to be systematically too faint. The standard stars were observed for much shorter times than the faint targets, they should be better centered on the slit, and better focused, and for setup A a wider slit was used for the standard stars than for the program objects.

4. STARS

Papers by Gunn & Stryker (1983) and Jacoby, Hunter & Christian (1984) were consulted to obtain rough stellar classifications. Berg et al. (1992) present a simple classification scheme which they used on their 6 Å FWHM optical spectra of QSO candidates. Beers et al. (1992a) present digital spectra covering 3700 – 4500 Å at 0.7 to 1.2 Å FWHM for various hot halo stars (A, DA, sdO, sdB, Horizontal Branch = HB), together with classification criteria, while Beers, Preston & Shectman (1992b, hereafter BPS2) present spectra of cooler halo F and G stars of various metallicities.

Greenstein (1980) discusses the difficulty of distinguishing white dwarfs (WDs) from hot halo (subdwarfs sdO or sdB, hot HB) stars. The separation is hardest for the hottest stars because the physical differences in temperature and gravity are also small, so that DAwk (weak Balmer lines) and sharp lined DAs can be confused with sdBs. But the distinction is easy below 12,000 K because the WDs then have stronger Balmer lines. Greenstein (1980) shows that any star with $W(H\gamma) \geq 15$ Å must be a DA, but as $W(H\gamma)$ drops from 15 to 5 Å, one has either DA stars of increasing T, or stars from the sequence HBA (HB type A), HBB, sdB and sdO, which is one of both increasing T and gravity. For the hot stars we searched for but did not find any He I 4026, 4388, and 4471, or He II 4686.

Our spectral classifications are given in Table 2. For the stars we list the spectral type implied by the spectral features, and then, in parentheses, that which would correspond to the $(B-V)$ if the star had solar metallicity. Most of the stars actually have significantly lower metallicities, so their $(B-V)$ colors are from 0.1 to 0.3 magnitudes bluer (e.g. Beers et al. 1990; hereafter BPSK) than those of solar abundance stars with the same M_V . This deblanketing effect accounts for why the spectra type deduced from the colors are hotter than those from the spectral features. Notes on the classification of individual objects are given in §6 below.

4.1 Stellar Metal Abundances

BPSK discussed a method of determining stellar metallicities which is a refinement of that first presented by Preston (1959). The equivalent width of the Ca II K line is used as the metallicity estimator, with weaker lines indicating lower metallicities. Since the strength of Ca II K also drops with the increasing stellar temperature, a temperature indicator, such as the Balmer line equivalent widths or a color index, is needed.

BPSK note that this method has several advantages: Ca II K is relatively independent of gravity, so one does not need to know whether the star is a dwarf or giant, $[\text{Ca}/\text{Fe}]$ is remarkably free of scatter at a given $[\text{Fe}/\text{H}]$, and the resulting abundances obtained from the Beers et al. 1 Å resolution spectra have an impressively small scatter of $\delta[\text{Fe}/\text{H}] \simeq 0.15$ dex for $0.33 \leq B - V \leq 0.85$ (F0 – K1) and $-4.5 \leq [\text{Fe}/\text{H}] \leq -1.0$. Even for cooler stars with $0.85 \leq B - V \leq 1.1$ (K1 – K5) the scatter is only 0.19 dex.

We have measured equivalent widths of lines in our spectra using the prescription of BPSK (their Table 1 and §4c). We used only the 18 Å bandpass for Ca II K and a 12 Å bandpass for the Balmer lines. The index KP' is the Ca II K equivalent width measured in the 18 Å interval, corrected for interstellar Ca II K absorption by subtracting 0.22 Å ($= 0.192 \text{ Å} / \sin 60^\circ$ from BPSK, but see also Bowen 1991). The Balmer line index

$$HP = -0.120 + 0.5H\delta + 0.555H\gamma, \quad (2)$$

is the average of the measured equivalent width of $H\delta$, and an estimate of that width based on the measured equivalent width of $H\gamma$. The G-band (CH) index GP is the equivalent width in the 15 Å band around 4300 Å.

We report values for these indices in Table 3. The Balmer line equivalent widths can be used to estimate stellar temperatures and colors. BPS2 (their Fig. 7, and eqn. 1) found that the relationship

$$(B - V)_0 = 0.962 - 0.292HP + 0.036HP^2 \quad (3)$$

applies for $0.35 \leq (B - V)_0 \leq 0.9$, (F2 – K2), with most sensitivity for the hottest stars. These estimates of $(B - V)_0$ can be compared with those from the slit photometry. The slit minus HP color differences, listed as Δ in Table 3, are unexpectedly small, with a mean of +0.008 and a standard deviation of only 0.04, which is only slightly worse than the prediction error of 0.^m03 quoted by BPS2 for their data. We had expected that our results would show much more scatter because we do not have proper photometric colors and we used a lower spectral resolution of 3.6 Å versus 1 Å, but apparently these are not serious deficiencies.

Metallicities can now be measured from Fig. 4 of BPSK, which shows KP' as a function of $(B - V)_0$ for various abundances. In Table 4 we list abundances appropriate for giants, subgiants, and dwarfs. If the stars are dwarfs then their abundances will be lower by up to 0.2 dex.

The metallicity errors that we list come entirely from the two different estimates of $(B - V)$. The actual random errors are probably about 0.3 dex and are dominated by the uncertainty in the Ca II K line equivalent widths. The main systematic error is probably an underestimate of metallicities of those stars with strong Ca II K. When Ca II K is very strong it spills outside the band pass defined by BPSK, and will have measured a systematically smaller KP' , and hence a lower metallicity, than BPSK because our spectra are of lower resolution. We have not attempted to correct this bias, which could be done by calibrating the KP' versus $(B - V)$ relationship for spectra with our resolution.

Two objects lie just outside the color range considered by BPSK. For 0009–003 we use the linear extrapolation (“patch”) for $[\text{Fe}/\text{H}] \geq -1.0$ discussed in §5 and presented in Table 4 of BPS2, while for 2358+004 we extrapolate by eye to obtain $[\text{Fe}/\text{H}] \simeq -0.5$.

The metallicities listed in Table 4 range from -0.5 to -2.6 , but 50% of the stars have $-1.9 \leq [\text{Fe}/\text{H}] \leq -1.7$ which is reasonable for faint (halo) stars selected to have UV excess.

4.2 Stellar G-Band Strength

We have measured the strength of the G-band CH feature in the spectra of the ten stars for which we have determined abundances. Beers, Preston & Shectman (1985, hereafter BPS1) found a range of equivalent width for the GP index which was similar to that found by others for globular cluster and halo stars, with weak G-band stars most often on the red HB to asymptotic giant branch, and strong G-band stars amongst the subgiants (Bond 1980).

BPS1 plot the distribution of G-band strength as a function of color for 105 of their stars with $[\text{Fe}/\text{H}] \leq -2.0$. Relative to this sample, many of our ten stars have unusually large GP. For example, 40% of our stars, but only 1% of theirs have $\text{GP} \geq 4.0$. This is partly because some of our stars have larger abundances, and partly because we lack the bluest of stars with $(\text{B}-\text{V}) \simeq 0.4$, and we have an excess of redder stars (which have stronger GP), but it does still seem that we might have a few stars including 0003+012B and 2357+009 with anomalously strong CH. Our approximate colors suggest that both of these stars are too red to be subgiants, but not by much: 0003+012B has $(\text{B}-\text{V}) \simeq 0.58$, and 2357+009 has $(\text{B}-\text{V}) \simeq 0.63$.

4.3 Stellar Distances

If we knew whether our stars were giants or dwarfs we could obtain rough estimates of their photometric distances, but our spectra and slit colors are not decisive.

The relative proportion of giants (absolute magnitude brighter than the main sequence turnoff of $M_V = 4.5$) to dwarfs depends on three factors: the ultraviolet excess bias in favor of low abundance, the ratio of giants to dwarfs in the disk and halo, and the apparent magnitudes of the stars.

Seven of our ten stars with the lowest abundances ($-2.5 \leq [\text{Fe}/\text{H}] \leq -1.7$) are likely to be in the halo because their abundances are too low for disk stars, and there are few halo stars currently passing through the disk. BPS1 argued that all of their low metallicity stars were halo objects, and they used the Bahcall-Soneira model of the Galaxy to estimate that about 90% of these were giants, favored because they sample a larger volume.

Our stars are much fainter than theirs, $18.1 \leq V \leq 19.7$, compared with $12.0 \leq V \leq 15.0$. The relative size of the volume sampled for dwarfs and giants remains unchanged with changing magnitude limit, but our sample will include a larger proportion of dwarfs because the density of dwarfs in the inner halo drops slower than that of giants in the outer halo.

Our estimates of the distances to our stars are given in Table 4. We use the absolute magnitudes specified in Table III of BPSK for dwarfs and giants separately. These distances range from 1.4 kpc to 7 kpc if the stars are dwarfs, and from 7 to 62 kpc if they are giants, but in either case only three stars could be beyond 15 kpc. Of these three, two have distances of 43 kpc and 62 kpc if they are giants. Stars are sufficiently rare at these distances that these two objects are much more likely to be dwarfs. Many of the stars are near the main sequence turnoff so their absolute magnitudes and hence their distances are less sensitive to whether they are dwarfs or giants, provided they are not horizontal branch stars.

5. QSO EMISSION AND ABSORPTION LINES

QSOs were identified by the presence of at least two emission lines, one of which might appear in the ZC spectra rather than ours because of the differences in wavelength coverage.

We list the wavelengths and observed frame equivalent widths for the QSO and galaxy emission lines in Table 5. Redshifts were weighted by the line equivalent widths. Absorption lines in the spectra of the QSOs are listed in Table 6. Individual cases are discussed in the next section.

6. NOTES ON INDIVIDUAL OBJECTS

0000+025A: QSO. – The spectrum clearly shows that this is a QSO with $z_{em}=1.6843$. Absorption lines at $\lambda 4343$, $\lambda 4374$ and $\lambda 5897\text{\AA}$ are probably caused by bad subtraction of strong sky emission lines. A possible broad absorption feature at $\lambda 6379$ is unidentified.

0000+027A: QSO. – ZC1 identified emission lines at 4203 and 5179 \AA as C IV and C III] respectively. They are actually $\text{Ly}\alpha$ and C IV, giving a higher redshift. There is a strong absorption line just to the red of the peak of the C IV emission line which is almost certainly associated C IV absorption, with $z_{abs} = 2.394$ and a rest frame equivalent of 3.0 \AA because of its strength and position.

0003+011A: star – M4. – The spectral features suggest M4 star, while the $(\text{B}-\text{V})$ is typical of a M2 star of solar abundance.

0003+011B: star – F. – The continuum falls off shortward of 5000 Å, and rises slightly into the red, indicating $T \leq 7000$ K. Ca II H and K are weak, and there is no break at 4000 Å.

0004–005B: QSO. – This QSO was identified as Q0004-0032 with $z_{em} = 1.72$ and $B_J = 18.4$ by Foltz et al. (1989). Their spectrum shows four strong emission lines. Two strong absorption lines at $\lambda \sim 5854$ and $\lambda \sim 5959$ are unidentified. They might be Mg II absorption systems.

0004+014: star – G. – Ca II H,K and Mg I triplet 5167, 5172.7, and 5183.6 are very strong. H α which is very weak, is the only visible Balmer line. Flux drops about 50% across 4000 Å.

0005+030: QSO. – ZC1 identified an emission line at 4000 Å as Ly α . It is actually C III] 1909, which is confirmed by our detection of Mg II at $z_{em} = 1.0948$ and blended Fe II features.

0006+020B: QSO. – This QSO was identified as Q0006+0200 with $z_{em} = 2.35$ and $B_J = 17.9$ by Foltz et al. (1989). ZC1 identified emission lines at 4149 and 5200 Å as C IV and C III] respectively. They are actually Ly α and C IV, at a higher redshift of 2.3483.

The two strong absorption lines in this spectrum at 4700Å and 5226Å and a possible weak line at 5076Å. The absorption feature at 5578Å is considered bogus because it is near to a strong sky line. The strong line at 4700Å and the weak line at 5076Å could be C IV and Al II at $z_{abs}=2.035$, but the Si II $\lambda 1526$ line which would be expected at 4634Å is not seen, and the second strong line is not identified. Alternatively, 4700 is Si IV $\lambda 1393$, 4735Å is Si IV $\lambda 1402$, and 5226Å is a blended C IV doublet. But then 4700Å must be a blend with another unidentified line because it is twelve times stronger than its doublet partner, compared to a maximum ratio of two. The Foltz et al. (1989) spectrum also shows the 4700 line. In a footnote to their table 2 they suggest possible associated absorption, presumably because they see absorption in the Ly α emission line, which is consistent with our interpretation of the 5226 line as C IV.

0006+022A: QSO. – ZC1 identified emission lines at 3910 and 5056 Å as Ly α and C IV respectively. They are actually C IV and C III] respectively, at $z_{em} = 1.5152$. We also observe the blue wing of the Mg II emission line which should be centered at about 7039 Å.

0006+025: QSO. – Foltz et al. (1989) called this QSO Q0006+0230. They saw Ly α and Si IV+O IV] emission lines in addition to the C IV and C III] which we saw, and obtained $z_{em} = 2.09$, consistent with our value of 2.0909. Their magnitude of $B_J = 18.00$ is to be preferred to our value of $B = 19.19$.

0008+008: QSO. – The peak of the Ly α emission line appears at too high a redshift because strong absorption lines destroy the blue side of the line peak. The colors listed in Table 3 are both much redder than those of typical QSOs because of the Ly α forest and the Lyman limit system.

A Lyman Limit edge is seen at $\lambda \sim 3750$ which corresponds to $z_{LLS}=3.08$. This system at $z_{abs} = 3.079$ is confirmed by strong corresponding Ly α and C IV doublet absorption lines. In addition there is an obvious damped Ly α absorption line at $\lambda \sim 4883.5$ Å ($z_{abs} \simeq 3.017$) with an observed equivalent width of about 96Å, which corresponds to a neutral hydrogen column density of $N(\text{HI}) \sim 10^{21} \text{ cm}^{-2}$. The metal line absorption system with $z_{abs}=3.028$ is likely to be associated with this damped Ly α line. Other metal systems including C IV at $z_{abs}=2.625, 2.650, 2.895$, and Mg II at $z_{abs}=1.194$ were found.

0008+010: star – G. – This star shows H α , H β , H γ and Ca II, all of which are very weak. There is no 4000 Å break and Ca II is stronger than Balmer lines. The estimated metallicity of $[\text{Fe}/\text{H}] \simeq -2.5$ is the lowest of our ten stars.

0010–002B: QSO. – ZC3 listed a weak emission line at 4203Å, a strong line at 3818 Å which they interpreted as Ly α (rest wavelength 1228 Å) at an emission redshift of 2.11. We see weak emission lines at 4872Å and 6004Å which we interpret as C IV and C III] at a redshift of 2.1462. A Foltz et al. (1989) spectrum of this object, which they call Q0010–0012, shows Ly α in addition to the weak C IV and C III] lines which we saw. They obtained $z_{em} = 2.15$, which is consistent with our redshift. They gave $B_J = 18.5$, which is more reasonable than our $B = 20.07$.

ZC3 also list an absorption line at 3669 Å, which is likely to be a strong (probably damped because it shows up in the prism spectrum) Ly α line at $z_{abs} = 2.017$. The Foltz et al (1989) spectrum also shows this line. We see a partially resolved pair of lines at 4690 Å and 4697.7 Å, which we interpret as the C IV doublet in this absorption system, with $z_{abs} = 2.030$ (see also the Foltz et al spectrum). We also see a possible doublet near 6300 Å which might be Mg II if it is not simply poor sky subtraction.

0010+008: QSO. – There is a possible Lyman limit edge at about 3500 – 3600 Å but the S/N is too low to see possible metal lines in this system.

0010+023: galaxy. – This emission line galaxy ($z_{em} = 0.0879$) was observed in both setups A and B. We see stellar absorption immediately surrounding the Balmer emission lines in the setup B spectrum.

0011–002A: galaxy. – In addition to the emission lines listed in Table 5, the 4000 Å break is also seen at the expected wavelength of 4463 Å.

0011–012A: star – sdB. – The Balmer lines are resolved and have large equivalent widths of $W(H\alpha) = 12.1$ Å, $W(H\beta) = 13.1$ Å, and $W(H\gamma) = 3.9$ Å. The spectrum rises to the blue, indicating $T \geq 11,000$ K, but the slit (B–V) of 0.18 indicates a much lower temperature of $T \simeq 8,000$ K.

The absorption feature at the extreme blue end of the spectrum near 4311 Å, and the shallower broad feature at 4370 Å are both bogus, the latter lying in the region of He I 4387. However He I 4471 Å, which is normally stronger, is not seen. $H\gamma$ at 4345 Å may be compromised by these detector problems.

The $W(H\gamma)$ line has a central depth of $R_c = 0.33$ of the continuum level (measured down from the continuum, so that deeper lines have larger values), a FWHM of 10.5 Å, and a width at 20% below the local continuum of $D(0.2) = 8.4$ Å. Both the width measurements have been corrected for the instrumental resolution, but we have not corrected the central depth, which should be greater than the measured value. The corrected width and uncorrected depth place the star amongst sdO, sdB and hot DA stars of Figure 2 of Beers et al. (1992). The line profile lacks the extensive wings expected of a white dwarf, but is very similar to a hot sdB (or cool sdO) star with $T=35,000$ K and $\log g = 5$ (Fig. 3 of Greenstein 1980). Since the line will be deeper than our measurement, the actual temperature is probably nearer to 25,000 K, and the star would be near to the blue HB. However these high temperatures are inconsistent with the (B–V), and neither the $H\gamma$ line nor the color can be considered reliable.

We can also measure the width of the $H\beta$ line at 0.9 of the continuum level, which increases with both temperature and gravity (Herbig 1992). The measured value of 36 Å implies $18,000 \leq T(K) \leq 26,000$ if the star is an sdB, since such stars have $5.0 \leq \log g \leq 5.7$, which is consistent with the $H\gamma$ profile, but not with the (B–V) color.

If it is an sdB (or blue HB) with an absolute magnitude of about $M_v \simeq +2$ (Greenstein & Sargent 1974), then it is in the halo at a distance of about 14 kpc, well beyond the disk sdB stars for which Heber (1986) derived a tentative scale height of 170 – 220 pc.

0012–002: QSO?. – The (B–V)=0.40 is typical of a QSO or hot (F3) star. There is a probable weak emission line at 4882 Å which is probably the moderate strength line which ZC2 note at 5076. ZC2 reported a second moderate line at 4028 which is outside our wavelength range. They interpreted these lines as C IV and $\Lambda\alpha$ giving a poor fit to $z_{prism} = 2.28$. We prefer $z_{em} = 1.557$ which identifies the lines as C III] and C IV, but this is very uncertain.

0012+011: star?. – Only the Na I D line is seen in this very low S/N spectrum, and even this is uncertain because it lies on top of the strong sky emission line. The (B–V)=1.08 is too red for a normal QSO, but resembles a cool (about K4) star, which would show strong Na I D. The absence of absorption around 5180 Å suggests that the star can not be cooler than K4, unless its metallicity is low, which is possible.

2350-019A: DA4 white dwarf. – This new white dwarf shows strong Balmer lines up to H5. Its continuum flux peaks between 4200 and 4800 Å, which implies temperatures of 10,600 to 12,100 K, corresponding to DA5 to DA4 (Dx, where $x \equiv 50,400/T$ K; Sion et al. 1983). The slit (U–B) and (B–V) colors are consistent with DA3 – DA5, and the $H\beta$ line strength and profile correspond to DA3 to DA5. The line equivalent

widths are: $W(H\alpha) = 95.7 \text{ \AA}$, $W(H\beta) = 55.6 \text{ \AA}$, $W(H\gamma) = 51.8 \text{ \AA}$, and $W(H\delta) = 11.5 \text{ \AA}$. Greenstein (1980) shows that the huge equivalent width of $W(H\gamma)$ means that the star must be a white dwarf, and that the temperature should be in the range 12,000 – 15,000 K (DA4 – DA3). The spectrophotometry of Greenstein (1984) suggests that this star would have $(G-R) \simeq -0.14$ and $M_v \simeq 12.6$, which implies a distance of 170 pc, less than the white dwarf disk scale height of about 220 – 270 pc (Green, 1980)

2359+026: unclassified. – The S/N is very low and no definite features are seen. The apparent emission features at $\lambda 4159$ and $\lambda 5065.6$ are both considered bogus because both lie near CCD defects, while the latter is near a strong sky line. Our slit colors for this object, $(B-V)=0.25$, $(U-B)=-0.69$, suggest that it is hot hotter in $(U-B)$ than any of the halo stars shown in Figure 6 of BPS2, and are consistent with a DA5 – DA6 WD, although the colors are about 0.1 magnitudes redder in $(B-V)$ or bluer in $(U-B)$ than most WDs. It could also be a BL Lac object since the colors are very near the mean for QSOs.

7. DISCUSSION

Zhan & Chen have noted (ZC5) that the fraction of their QSO candidates with $z_{em} \simeq 3$ was too large, and they commented that this was partly due to their interest in finding such high z objects.

We have found that only two of twenty-five candidates with $z_{prism} \geq 2.8$ are high redshift QSOs (8%). Their success rate is much better for lower z_{prism} , with eight QSOs out of eleven candidates (73%). Unfortunately the ZC prism redshifts are often incorrect because of incorrect emission line identifications. Only five of the eleven confirmed QSOs are at redshifts within 0.5 of the z_{prism} values, although for these five the z_{prism} were very good, differing from z_{slit} by only 0.03 – 0.06.

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- . 1989, Act. Ap. Sin. 9 147; trans. in Chin.A.Ap., 13, 321 (ZC4)
- . 1989, Chin.A.Ap., 9, 313 (ZC5)

FIGURE CAPTIONS

Fig. 1.– Spectra of the QSO candidates. The flux is f_ν , in units of micro-Jansky. The data have not been smoothed, and individual pixels are shown. The spectra are grouped by setup (A, then B, then C) and are in RA order for their setup. Features, both absorption and emission, which are present in most spectra of a given setup are often caused by erroneous sky emission line subtraction.

We show enlargements of the blue ends of several of the spectra. When a raised zero level is required it is shown by the raised horizontal dotted line, which extends under only the enlargement. The relationship of the flux plotted in an enlargement to the measured flux is given by the equation under that enlargement.

Fig. 2.– The difference between our slit B magnitudes and ZC's Schmidt plate image size B_J magnitudes. Slit magnitudes from setup A are shown as open circles, setup B as open squares, and C as filled dots.

TABLE 1
JOURNAL OF OBSERVATIONS

Object	Date (U.T.)	Integration Time (s)	Setup	Wavelength Range ^a (Å)		Ref. ^b
				Blue	Red	
0000+025A	1988-10-04	600	A	3843-7022		ZC1
0000+027A	1990-08-27	3600	B	4312-7056		ZC1
0002+022	1992-10-24	2000	C	3320-5470	5530-8305	ZC1
0002+030A	1992-10-24	2000	C	3320-5450	5520-8305	ZC1
0003+011A	1988-10-04	600	A	3843-7018		ZC1
0003+011B	1988-10-04	600	A	3843-7018		ZC1
0003+012B	1992-10-24	2000	C	3320-5475	5530-8305	ZC1
0004-004	1988-10-04	600	A	3843-7022		ZC2
0004-005B	1990-08-24	4000	B	4312-7059		ZC2
0004+014	1992-10-24	2000	C	3320-5475	5530-8300	ZC1
0005+003	1992-10-24	2000	C	3320-5485	5530-8310	ZC1
0005+030	1990-08-24	700	B	4312-7059		ZC1
0006+020B	1990-08-27	3000	B	4312-7056		ZC1
0006+022A	1990-08-27	3600	B	4312-7056		ZC1
0006+025	1990-08-27	3600	B	4312-7056		ZC1
0008+008	1992-10-24	2000	C	3320-5485	5530-8310	ZC1
0008+010	1992-10-24	2000	C	3320-5480	5530-8310	ZC1
0009-003	1992-10-24	2000	C	3320-5450	5530-8310	ZC2
0009+027B	1988-10-04	600	A	3843-7022		ZC1
	1990-08-24	500	B	4312-7059		ZC1
0010-002B	1988-10-04	600	A	3843-7006		ZC2
0010+008	1992-10-24	2000	C	3320-5485	5530-8290	ZC1
0010+023	1988-10-04	600	A	3843-7006		ZC1
	1990-08-24	2300	B	4312-7059		ZC1
0011-002A	1988-10-04	600	A	3843-7018		ZC2
0011-002B	1988-10-04	600	A	3843-7018		ZC2
0011-012A	1990-08-24	600	B	4312-7059		ZC2
0011+016	1988-10-04	600	A	3843-7018		ZC1
0012-002	1990-08-24	600	B	4312-7059		ZC2
0012+011	1990-08-27	3000	B	4312-7056		ZC1
2348-011A	1992-10-23	600	C	3320-5485	5530-8310	ZC4
2349-012	1992-10-23	1000	C	3320-5485	5530-8310	ZC4
2350-019A	1992-10-23	1000	C	3320-5480	5540-8275	ZC4
2356+007	1992-10-23	1000	C	3320-5485	5530-8310	ZC3
2357-005A	1992-10-23	2000	C	3320-5485	5530-8275	ZC4
2357+009	1992-10-23	2000	C	3320-5485	5520-8300	ZC3
2358-011	1992-10-23	2000	C	3320-5480	5530-8310	ZC4
2358+004	1992-10-23	2000	C	3320-5450	5530-8310	ZC3
2358+029A	1992-10-25	2000	C	3320-5480	5530-8295	ZC3
2359+026	1992-10-25	2000	C	3320-5485	5530-8270	ZC3

^a UV Schmidt has only one wavelength setting, whereas Kast is a double spectrograph.

^b Reference for coordinates and finding charts.

TABLE 2
SUMMARY OF SPECTRA

Object	Prism z_{em}^a	Q ^a	Type ^b	z_{em}	Spectral Lines
0000+025A	3.15	5	QSO	1.6843	C IV, C III] emission
0000+027A	1.71	5	QSO	2.3840	C IV, C III] emission
0002+022	3.17	5	star:F(F7)	...	Ca II H & K, H α , H β , H γ etc. absorption
0002+030A	3.15	5	star:G(F8)	...	Ca II H & K, H α , G-band absorption
0003+011A	...	4	star:M5(M2)	...	Ti O, Na I absorption
0003+011B	3.17	5	star:F(F3)	...	H β absorption, weak or absent Ca II, H α , H γ
0003+012B	3.12	6	star:G(G0)	...	Ca II H & K, H α , H β , Mg I, G-band absorption
0004-004	3.12	5	star:K(K0)	...	Ca II H & K, G-band absorption
0004-005B	1.75	5	QSO	1.7195	He II, O III] and C III] emission
0004+014	3.14	5	star:G/K(K1)	...	Ca II H & K, H α , Mg I, G-band absorption
0005+003	3.00	5	galaxy	0.0932	Ca II H & K redshifted
0005+030	2.26	5	QSO	1.0948	Mg II, Fe II emission
0006+020B	1.70	5	QSO	2.3483	Si IV+O VI], C IV and C III] emission
0006+022A	2.22	6	QSO	1.5152	C III] emission
0006+025	2.14	5	QSO	2.0909	C IV, C III] emission
0008+008	3.15	5	QSO	3.0837	Ly α , C IV, C III] emission
0008+010	3.12	5	star:G(F8)	...	Ca II H & K, H α , H β , H γ absorption, no G-band
0009-003	3.02	5	star:F(F6)	...	Ca II H & K, H α , H β , H γ etc. absorption
0009+027B	3.17	5	star:G(F5-G0)	...	Ca II H & K, H α , H β absorption
0010-002B	2.11	5	QSO	2.1453	C IV & C III] emission
0010+008	3.11	5	QSO	3.076	Ly α , N V, Si IV+O VI], C III] and C IV emission
0010+023	2.27	5	galaxy	0.0879	H β , H γ , [O II], O III] etc. emission
0011-002A	3.10	5	galaxy	0.1158	[O II] & H β emission
0011-002B	...	4	star:K(K4)	...	Ca II H & K, H α , H β , Mg I, G-band absorption
0011-012A	2.23	5	star:sdB(A6)	...	strong, broad H α , H β , H γ absorption, no He I λ 4471
0011+016	3.22	5	star:G(F8)	...	Ca II H & K, H α , H β , H γ absorption
0012-002	2.28	5	QSO	1.557?	possible C III] emission
0012+011	1.67	5	star:K(K4)	...	possible Na I absorption, low S/N
2348-011A	3.07	5	star:G(F5)	...	Ca II H & K absorption
2349-012	3.12	5	star:G(G8)	...	Ca II H & K, H α , H β absorption
2350-019A	3.10	5	WD:DA4(A3)	...	Balmer absorption up to H5
2356+007	3.17	5	star:M3(M3)	...	Ti O, Ca II H & K absorption
2357-005A	2.83	5	galaxy	0.106	H α , [O II] emission
2357+009	3.05	5	star:G(G2)	...	Ca II H & K, H α , H β absorption
2358-011	3.22	5	star:G(F7)	...	Ca II H & K, H α , H β absorption
2358+004	2.94	5	star:G(G3)	...	Ca II H & K, H α absorption
2358+029A	3.13	5	star:M3(M5)	...	Ti O, Na I absorption
2359+026	3.14	5	?:?(A7)	...	low S/N flat spectrum, featureless

^a Objective prism redshift and the reliability index Q are from the ZC references listed in Table 1.

^b The first stellar type is from the spectral features and the second, in parenthesis, is from (B-V)₀.

TABLE 3
MAGNITUDES AND SPECTRAL INDICES

Object	B_f^a	U^b	B^b	V^b	$(B-V)_0^b$	$(B-V)^c$	Δ^d	HP^e	KP'^e	GP^e
0000+025A ^g	17.5	...	18.88	18.71	0.15	...	...	...	...	...
0000+027A	18.0	...	21.03	20.14	0.87	...	...	...	...	...
0002+022	18.0	18.28	18.64	18.15	0.48	0.53	-0.05	1.92	5.23	0.69
0002+030A	18.5	19.85	20.26	19.70	0.54	...	...	...	...	...
0003+011A ^g	18.0	...	19.75	18.22	1.51	...	...	...	...	...
0003+011B ^g	18.0	...	18.77	18.44	0.42	...	...	...	...	...
0003+012B	18.0	18.43	18.69	18.12	0.55	0.62	-0.07	1.44	7.91	3.03
0004-004 ^g	17.5	...	18.58	17.79	0.78	...	...	...	...	...
0004-005B	18.0	...	18.70	18.30	0.39	...	...	...	...	...
0004+014	18.5	19.68	19.31	18.39	0.90	0.85	0.05	0.39	9.43	5.35
0005+003	17.5	19.83	19.47	18.23	1.22	...	...	...	...	...
0005+030	17.0	...	16.72	16.10	0.60	...	...	...	...	...
0006+020B	17.5	...	18.44	17.75	0.68	...	...	...	...	...
0006+022A	18.0	...	19.49	19.11	0.37	...	...	...	...	...
0006+025	17.5	...	19.19	18.75	0.43	...	...	...	...	...
0008+008	19.5	21.53	20.05	18.87	1.16	...	...	...	...	...
0008+010	19.0	19.02	19.32	18.77	0.53	0.53	0.00	1.92	2.94	1.45
0009-003	18.0	18.41	18.77	18.29	0.47	0.45	0.02	2.55	6.46	1.05
0009+027B ^f	16.0	...	17.55	16.95	0.58	...	...	...	...	...
0009+027B ^g	16.0	...	18.39	17.93	0.44	...	...	...	...	...
0010-002B ^g	18.0	...	20.07	19.43	0.63	...	...	...	...	...
0010+008	19.5	21.84	20.42	19.67	0.74	...	...	...	...	...
0010+023 ^f	15.5	...	17.85	17.25	0.58	...	...	...	...	...
0010+023 ^g	15.5	...	18.53	17.95	0.56	...	...	...	...	...
0011-002A ^g	17.5	...	19.37	18.19	1.17	...	...	...	...	...
0011-002B ^g	17.5	...	18.41	17.36	1.04	...	...	...	...	...
0011-012A	17.0	...	17.90	17.69	0.18	...	...	...	...	...
0011+016 ^g	17.5	...	18.28	17.73	0.54	...	...	...	...	...
0012-002	18.0	...	17.60	17.19	0.40	...	...	...	...	...
0012+011	18.0	...	19.19	18.10	1.08	...	...	...	...	...
2348-011A	18.5	19.09	19.33	18.86	0.45	0.47	-0.02	2.36	3.74	2.51
2349-012	16.5	18.62	18.59	17.85	0.73	0.71	0.02	0.85	8.05	4.07
2350-019A	18.5	17.89	18.80	18.70	0.09	...	...	...	...	...
2356+007	18.5	20.17	19.29	17.73	1.54	...	...	...	...	...
2357-005A	18.0	20.33	20.83	20.07	0.74	...	...	...	...	...
2357+009	17.0	20.19	20.40	19.71	0.66	0.61	0.05	1.46	5.68	5.03
2358-011	17.5	19.25	19.35	18.81	0.52	0.46	0.06	2.51	4.07	2.26
2358+004	17.0	19.51	19.57	18.89	0.66	0.64	0.02	1.33	11.88	5.10
2358+029A	17.5	21.34	19.87	18.16	1.69	...	...	...	...	...
2359+026	17.0	19.33	19.99	19.61	0.36	...	...	...	...	...

^a From the ZC reference listed in Table 1.

^b Highly uncertain because they are derived from narrow slit spectra, discussed in §3.2.

^c Estimated from the Balmer line index HP using eqn. (3).

^d Slit (B-V) minus HP index (B-V).

^e The H δ , Ca II K and G-band equivalent width (\AA), defined in §4.1.

^f Magnitudes were measured from Setup B spectrum.

^g Magnitudes were measured from Setup A spectrum, and likely to be systematically too faint.

TABLE 4
STELLAR ABUNDANCES AND DISTANCES

Object	Giant		Dwarf	
	[Fe/H]	d(kpc)	[Fe/H]	d(kpc)
0002+022	-1.7 ± 0.2	9.0 ^a	-1.7 ± 0.2	3.7
0003+012B	-1.3 ± 0.1	8.5 ^a	-1.4 ± 0.2	2.9
0004+014	-1.9 ± 0.1	62.2	-2.1 ± 0.1	1.4
0008+010	-2.5	14.4 ^a	-2.6	4.0
0009-003	-1.0 ± 0.2	6.7 ^a	-1.0 ± 0.2	6.6
2348-011A	-1.8 ± 0.2	12.1 ^a	-2.0 ± 0.1	5.8
2349-012	-1.8 ± 0.1	23.3	-2.0 ± 0.1	1.6
2357+009	-2.2 ± 0.1	42.7	-2.2 ± 0.1	4.6
2358-011	-1.9 ± 0.3	12.8 ^a	-2.0 ± 0.1	4.9
2358+004	-0.5:	...	-0.5:	...

^a Subgiants, near the main sequence turnoff.

TABLE 5
EMISSION LINES

Ion	λ_{lab}^a	λ_{obs}^a	W_{obs}	z_{em}
0000+025A				
C IV	1549.06	4158.4	70	1.6845
C III]	1908.73	5123.2	56	1.6841
$\langle z_{\text{em}} \rangle = 1.6843$				
0000+027A				
C IV	1549.06	5237.9	98	2.3835
C III]	1908.73	6460.3	77	2.3846
$\langle z_{\text{em}} \rangle = 2.384$				
0004−005B				
He II	1640.43	4462.0	8	1.7200
O III]	1663.99	4537.3	8	1.7268
C III]	1908.73	5187.9	42	1.7180
$\langle z_{\text{em}} \rangle = 1.7195$				
0005+003 (absorption lines only)				
Ca II	3934.78	4301.6	14.6	0.0932
Ca II	3969.59	4339.5	14.6	0.0932
G-band	4301.2:	4706.5	6.2	0.0942
H β	4862.68	5315.6	5.3	0.0931
Na I D	5894.56	6442.2	2.6	0.0929
$\langle z_{\text{abs}} \rangle = 0.0932$				
0005+030 ^b				
Mg II	2798.74	5863.0	44	1.0948
0006+020B				
Si IV+O IV]	1398.62	4693.0	22	2.3555
C IV	1549.06	5186.7	38	2.3483
C III]	1908.73	6391.0	50	2.3483
$\langle z_{\text{em}} \rangle = 2.3483$				
0006+022A ^b				
C III]	1908.73	4800.9	46	1.5152

TABLE 5 – *continued*

Ion	λ_{lab}^a	λ_{obs}^a	W_{obs}	z_{em}
0006+025				
C IV	1549.06	4787.5	102	2.0906
C III]	1908.73	5900.4	57	2.0913
$\langle z_{\text{em}} \rangle = 2.0909$				
0008+008				
Ly α	1215.67	4977.4	285	3.0944 ^b
C IV	1549.06	6324.8	163	3.0830
O III]	1643.99	6794.7	25	3.0843
C III]	1908.73	7796.7	100	3.0848
$\langle z_{\text{em}} \rangle = 3.0837$				
0010–002B				
C IV	1549.06	4873.1	40	2.1458
C III]	1908.73	6005.6	87	2.1464
$\langle z_{\text{em}} \rangle = 2.1462$				
0010+008				
Ly β	1025.72	4190.2	102	3.0851
Ly α	1215.67	4963.7	148	3.0831
N V	1240.13	5048.9	40	3.0712
Si IV+O IV]	1398.64	5688.3	45	3.0670
C IV	1549.06	6303.6	94	3.0693
C III]	1908.73	7786.6	65	3.0795
$\langle z_{\text{em}} \rangle = 3.076$				
0010+023				
Setup A				
[O II]	3728.06	4065.6	36.8	0.0905
[Ne III]	3870.10	4209.7	8.5	0.0877
H γ	4341.68	4726.8	4.9	0.0887
H β	4862.68	5291.3	17.2	0.0881
[O III]	4960.28	5398.5	8.4	0.0883
[O III]	5008.20	5449.1	18.9	0.0880
He I	5877.63	6393.3	5.0	0.0877
$\langle z_{\text{em}} \rangle = 0.0889$				

TABLE 5 – *continued*

Ion	λ_{lab}^a	λ_{obs}^a	W_{obs}	z_{em}
Setup B (better spectrum)				
H γ	4341.68	4721.6	1.3	0.0875
H β	4862.68	5290.1	15.6	0.0879
[O III]	4960.28	5396.3	5.7	0.0879
[O III]	5008.20	5448.4	16.6	0.0879
He I	5877.63	6393.2	2.6	0.0877
[O I]+[S III]	6301.74	6855.7	3.0	0.0879
$\langle z_{\text{em}} \rangle = 0.0879$				
0011–002A ^b				
[O II]	3728.06	4159.9	13.8	0.1158
H β	4862.68	5424.6	4.7	0.1156
$\langle z_{\text{em}} \rangle = 0.1158$				
0012–002 ^b				
C III]	1908.73	4881.7	26	1.5576
2357–005A				
[O II]	3728.06	4122.6	23.4	0.1058
H α	6564.56	7257.9	37	0.1056
[N II]	6584.82	7281.9	9.8	0.1059
[S II]	6718.85	7428.5	17	0.1056
[S II]	6735.86	7443.1	19	0.1050
$\langle z_{\text{em}} \rangle = 0.1056$				

^a These are vacuum wavelength.

^b See notes on individual objects.

TABLE 6
MAJOR ABSORPTION LINES IN THE QSO SPECTRA

QSO	No.	λ_{obs}^a	W_{obs}	Identification	z_{abs}
0000+025A	1	6382.0	11.2	...	...
0000+027A	1	5257.3	10.1	C IV ($\lambda 1548$) ^b	2.394
0004–005B	1	5854.3	4.5	...	...
	2	5959.2	5.2	...	...
0006+020B	1	4700.6	7.1	C IV ($\lambda 1548$) ^{b,c}	2.034
				Si IV ($\lambda 1393$) ^c	2.373
	2	4735.5	0.6	Si IV ($\lambda 1402$) ^c	2.376
	3	5073.8	1.7	Al II ($\lambda 1670$) ^c	3.037
				Fe II ($\lambda 2382$) ^c	1.129
	4	5225.9	2.7	C IV ($\lambda 1548$) ^{b,c}	2.374
	5	5578.3	2.0	...	...
	6	5960.7	1.2	Mg II ($\lambda 2796$)	1.131
	7	5975.5	0.7	Mg II ($\lambda 2803$)	1.131
			
0006+025	1	6438.8	2.7	...	...
0008+008	1	4883.5	96.3	H I ($\lambda 1215$)	3.017
	2	4962.0	12.3	H I ($\lambda 1215$)	3.082
	3	5613.7	3.6	C IV ($\lambda 1548$)	2.626
				Si IV ($\lambda 1393$)	3.028
	4	5622.2	1.2	C IV ($\lambda 1550$)	2.625
	5	5650.3	3.2	C IV ($\lambda 1548$)	2.650
				Si IV ($\lambda 1402$)	3.028
	6	5659.5	1.6	C IV ($\lambda 1550$)	2.650
	7	6030.0	1.8	C IV ($\lambda 1548$)	2.895
	8	6039.3	0.7	C IV ($\lambda 1550$)	2.894
	9	6134.1	2.1	Mg II ($\lambda 2796$)	1.194
	10	6150.4	2.3	Mg II ($\lambda 2803$)	1.194
	11	6238.0	7.0	C IV ($\lambda 1548$)	3.029
	12	6248.6	4.1	C IV ($\lambda 1550$)	3.029
	13	6314.1	6.8	C IV ($\lambda 1548$)	3.078
	14	6325.7	4.3	C IV ($\lambda 1550$)	3.079
	15	6730.6	3.9	Al II ($\lambda 1670$)	3.028
	16	7471.9	1.4	Al III ($\lambda 1854$)	3.028
	17	7503.7	3.1	Al III ($\lambda 1862$)	3.028

TABLE 6 — *continued*

QSO	No.	λ_{obs} ^a	W_{obs}	Identification	z_{abs}
0010–002B	0	3669 ^d	...	H I (λ 1216)	2.017
	1	4691.3	7.0	C IV (λ 1548)	2.030
	2	4699.0	6.3	C IV (λ 1550)	2.030
	3	5075.4	9.0	...	...
	4	6286.4	3.9	Mg II (λ 2976)	1.248
	5	6300.6	5.2	Mg II (λ 2803)	1.247

^a Vacuum wavelength.

^b Blended with C IV λ 1550.

^c See §6.

^d Seen by ZC2.

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